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MATHÉMATIQUES

LE PROBLÈME DE CAUCHY DANS L'ESPACE DES FONCTIONNELLES

Par S. L. SOBOLEV, Membre correspondant de l'Académie

Dans cet article nous donnons une généralisation du problème classique de Cauchy sur l'intégration de l'équation

$$Lu = \sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}\frac{\partial^2 u}{\partial x_i \partial x_j} + \sum_{i=1}^{n} B_i \frac{\partial u}{\partial x_i} + Cu - \frac{\partial^2 u}{\partial t^2} = F \qquad (1)$$

de type hyperbolique normal à coéfficients analitiques pour les condition initiales

$$u\Big|_{t=0} = u^{(0)};\quad \frac{\partial u}{\partial t}\Big|_{t=0} = u^{(1)}. \qquad (2)$$

Cette généralisation consiste à envisager u comme une fonctionnelle linéaire dans un espace linéaire choisi d'une façon appropriée.

De cette façon le problème de Cauchy aura toujours une solution unique, coïncidant avec la solution classique, pourvu que cette dernière existe. L'existence en peut être établie sous quelques conditions spéciales portant sur les fonctions $u^{(0)}$, $u^{(1)}$ et F.

Précisons ces propositions sommaires.

Désignons par Ψ_s l'ensemble de toutes les fonctions ψ des variables indépendantes $x_1, x_2, \ldots x_n, t$ ayant des dérivées continues jusqu'à l'ordre s et s'annulant à l'extérieur d'un conoïde caractéristique de (1). Ce conoïde ne sera pas fixé et pourra changer d'une fonction à l'autre, mais doit avoir son sommet dirigé du côté des t positifs.

L'ensemble Ψ_s sera un éspace linéaire si nous adoptons une définition appropriée de la convergence.

La suite ψ_n des éléments de Ψ_s soit dite convergente vers un élément ψ de Ψ_s, si ψ_n tend uniformément vers ψ avec toutes ces dérivées jusqu'à l'ordre s inclusivement dans chaque domaine fini, et si d'ailleurs tous les domaines U_ψ sont contenus dans un seul conoïde caractéristique U.

Une fonctionnelle additive et continue dans Ψ_s soit dite fonctionnelle linéaire.

Soit U_s l'ensemble de toutes les fonctionnelles dans Ψ_s.

Nous disons qu'une suite de fonctionnelles ρ_n de U_s converge faiblement vers ρ de U_s si

$$(\rho_n,\ \phi) \longrightarrow (\rho,\ \phi)$$

pour chaque ϕ de Ψ_s.

Une suite convergente tirée de Ψ_s appartient évidemment à chaque Ψ_r $0 \leqslant r \leqslant s$ et sera là encore convergente.

De cette façon nous avons

$$\Psi_0 > \Psi_1 > \ldots \tag{3}$$

D'une façon analogue chaque suite faiblement convergente tirée de U_s appartient à chaque U_r, $r \geqslant s$, c.-à-d.

$$U_0 < U_1 < \ldots \tag{4}$$

Sous le terme d'opération linéaire dans l'espace Ψ ou U nous entendons une opération additive qui transforme chaque suite convergente dans Ψ_{s_1} en une suite convergente dans $\Psi_{s_2(s_1)}$. (La fonction $s_2(s_1)$ que nous nommons fonction de continuité doit être définie au moins pour une valeur de s_1).

Dans la définition de l'opération linéaire dans U il faut remplacer le symbole Ψ_s par U_s.

Parmi les fonctionnelles U_s il s'en trouve quelques-unes pouvant être représentées sous la forme:

$$(u,\ \phi) = \int\int\int u(\mu)\,\phi(\mu)\,dR_{n+1}, \tag{5}$$

où $u(\mu)$ est une fonction mesurable donnée.

Nous allons identifier ces fonctionnelles avec la fonctionnelle u. (Il est aisé de voir que la fonction u doit être différente de zéro dans un domaine quelconque dont la partie commune avec chaque conoïde caractéristique est finie).

Nous démontrons que dans chaque espace U_s les fonctionnelles equivalentes à des fonctions ayant une infinité de dérivées continues sont denses partout.

Partant de là on peut construire d'une facon unique des opérations linéaires élémentaires comme la dérivation ou la multiplication par une fonction donnée et, par conséquent, toute opération différentielle linéaire ordinaire.

Nous arrivons à la définition de nos équation différentielles dans l'espace des fonctionnelles.

Sous le terme d'opération adjointe à l'opération donnée $L\phi$ nous entendons une opération $L^*\rho$ telle que l'on ait

$$(L^*\rho \cdot \phi) = (\rho \cdot L\phi). \tag{6}$$

Chaque opération linéaire sur les fonctions a une opération adjointe portant sur les fonctionnelles.

On peut vérifier que pour les opérations différentielles ordinaires cette définition coïncide avec la définition connue.

S'il existe une fonction qui soit la solution du problème de Cauchy pour $t > 0$, nous pouvons l'interpréter comme une fonctionnelle, en ajoutant encore la condition $u\Big|_{t<0} = 0$.

Les relations (1) et (2) donnent l'identité suivante:

$$(u \cdot L^* \psi) = \int\int\int F \psi \, R_{n+1} - \int\int_{t=0} u^{(0)} \frac{d\psi}{dt} \, dR_n + \int\int_{t=0} u^{(1)} \psi \, dR_n. \tag{7}$$

La partie droite de (7) peut être écrite sous forme de $(\rho \cdot \psi)_0$, où ρ est la fonctionnelle donnée.

En juxtaposant (6) et (7) nous obtenons:

$$Lu = \rho, \tag{8}$$

où ρ est une fonctionnelle donnée de U_1.

Le problème de Cauchy est ainsi réduit à la recherche de la solution de (8). La construction de cette solution se réduit à son tour à la recherche de l'opération inverse de L. On peut construire cette opération en se servant, p. ex., de l'algorithme de l'auteur donné dans les C. R. Acad. Sci. URSS ([1], [2]).

De cet algorithme on déduit la construction de l'opération G qui satisfait à l'équation

$$GLu = u \tag{9}$$

déterminée pour toutes les fonctions u ayant les $\frac{n-3}{2}$ dérivées continues. G est ainsi définie sur un ensemble dense partout. En renversant le problème nous construisons pour les fonctions ψ l'opération G^* qui satisfait à l'équation

$$G^* L^* \psi = \psi. \tag{10}$$

La fonction de continuité pour G^* sera:

$$s_2(s_1) = s_1 - \frac{n-3}{2}. \tag{11}$$

L'opération G' conjuguée à G^* sera déterminée pour tous U_s.

La fonction de continuité en sera

$$s_2 = s_1 + \frac{n-3}{2}. \tag{12}$$

La propriété fondamentale s'en exprime ainsi:

$$LG' u = u \tag{13}$$

En tenant compte que

$$GLG' \rho = G\rho = G' \rho, \tag{14}$$

nous voyons que G' coïncide avec G sur un ensemble dense partout. Il s'en suit alors pour les point de cet ensemble:

$$G' Lu = u. \tag{15}$$

En nous rapprochant vers une fonctionnelle arbitraire sur les éléments de cet ensemble nous allons voir que (15) est vrai partout.

De (12) et de (15) s'en suit l'existence et l'unicité de la solution du problème de Cauchy généralisé.

Il n'est pas difficile non plus d'établir les conditions pour lesquelles notre solution sera également une solution dans le sens classique.

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PHYSICS

CALCULATION OF THE SELF-CONSISTENT FIELD WITH EXCHANGE FOR LITHIUM

By V. A. FOCK, Corresponding Member of the Academy, and M. I. PETRASHEN

The aim of this work was to make an estimation of the improvements in the results of calculation on atoms, introduced by taking into account the quantum exchange.

The desired estimation could be attained by comparing the results of calculations by the self-consistent field method (later on abbreviated as s. c. f. method) with and without exchange. A method of practical application of the s. c. f. method with exchange was worked out by means of calculation on sodium (1). When the work, reported here, was in progress, no other numerical results were attainable.

Consequently, it was indispensable to carry out the appropriate calculations for at least one alkali atom more. For this purpose we have chosen lithium.

The wave functions for the normal and four excited stats (for $l=1, n=2$, 3, 4, 5) of neutral lithium were constructed by the generalized s. c. f. method, and by means of these the corresponding term values and the transition probabilities for the principal series of Li were calculated. A comparison of the numerical results for Li and Na term values calculated by s. c. f. method with and without exchange with the observed energy values of the series electrons revealed the fact that in some cases about 90 p. c of the difference between the latter and those calculated by the s. c. f. method without exchange was due to the neglect of quantum exchange. The agreement of the observed energy values with the eigenvalues of the equation of s. c. f. with exchange was rather close, being about 2 p. c. for Na and 1 p. c. for Li.

As the results of calculations of the transition probabilities by the s. c. f. method had been far from satisfactory (2), it was of special interest for us to decide the question whether the wave functions of the generalized s. c. f. method are fit for these calculations.

It appeared that these functions afford the possibility of calculating the intensity of the head line of every series with great precision. The decrease

of the precision in the values of the intensities of higher lines could be accounted for and qalitatively these values could be estimated correctly, revealing for Li, for instance, a correct regularity in the values of the transition probabilities,—a regularity which distinguishes the principal series of Li from the corresponding series of other alkali atoms.

A full account on this work and the numerical results will soon appear elsewhere.

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PHYSIK

DIE BROWNSCHE BEWEGUNG DER SAITE

Von G. A. KRUTKOW, Korrespondierendem Mitglied der Akademie

1. Bekanntlich haben Uhlenbeck und Van Lear Erwartungswerte für das Quadrat der Verrückung einer Saite oder eines elastischen Stabes berechnet (1). Die allgemeine Lösung des Problems der Brownschen Bewegung eines Vibrators (2) gestattet ganz ohne Mühe auch die Wahrscheinlichkeiten für die Verrückungen (oder die Geschwindigkeiten) anzugeben, d. h. die Aufgabe allgemein zu lösen. Um ein Beispiel der diesbezüglichen einfachen Betrachtungen zu geben beschränken wir uns hier auf den Fall der Saite und ihrer Verrückungen.

2. Ist die lineare Dichte der Saite konstant, so kann ihre Differentialgleichung auf die Form

$$\frac{\partial^2 u}{\partial t^2} + 2h\frac{\partial u}{\partial t} = \frac{\partial}{\partial x}\left(p\frac{\partial u}{\partial x}\right) + F(x, t) \qquad (1)$$

gebracht werden, wo h eine Konstante und p eine Funktion von x ist. Die Saite sei etwa beiderseits elastisch befestigt oder eingespannt, es gelten also die Randbedingungen

$$\frac{\partial u}{\partial x} - H_0 u \Big|_{x=0} = 0, \quad \frac{\partial u}{\partial x} + H_1 u \Big|_{x=l} = 0, \quad (H_0, H_1 = \text{Konstanten}),$$

resp.

$$u \Big|_{x=0} = 0, \; u \Big|_{x=l} = 0.$$

Für uns ist wesentlich nur, dass in allen Fällen die Lösung als Reihe

$$u(x, t) = \sum_1^\infty X_r(x)\, q_r(t) \qquad (2)$$

erscheint. Die $X_r(x)$ bilden ein vollständiges orthogonales Funktionensystem, die $q_r(t)$ genügen den Differentialgleichungen

$$\ddot{q}_r + 2h\dot{q}_r + n_r^2 q_r = F_r(t), \tag{3}$$

wo die $F_r(t)$ aus der Entwicklung

$$F(x,t) = \sum_1^\infty X_r(x) F_r(t) \tag{4}$$

zu entnehmen sind.

3. Die Theorie der Brownschen Bewegung des Vibrators liefert für die Wahrscheinlichkeit, dass q_r zur Zeit t im Intervall $(q_r,\ q_r + dq_r)$ liegt, wenn für $t = 0$ q_r und $\dot{q}_r$ die Werte q_r^0, $\dot{q}_r^0$ besitzen, den Ausdruck [3]

$$(q_r,\ dq_r) = \frac{1}{\sqrt{\pi B_r}} e^{-\frac{Q_r^2}{B_r}} dq_r; \tag{5}$$

hier ist

$$B_r = \frac{h}{2a\alpha_r^2}\left[\frac{1-e^{-2(h+\alpha_r)t}}{h+\alpha_r} + \frac{1-e^{-2(h-\alpha_r)t}}{h-\alpha_r} - \frac{2(1-e^{-2ht})}{h}\right] \tag{6}$$

und

$$Q_r = q_r - \left\{\frac{e^{-(h-\alpha_r)t}}{2\alpha_r}[\dot{q}_r^0 + (h+\alpha_r)q_r^0] - \frac{e^{-(h+\alpha_r)t}}{2\alpha_r}[\dot{q}_r^0 + (h-\alpha_r)q_r^0]\right\} \tag{7}$$

mit

$$\alpha_r^2 = h^2 - n_r^2,\ a = \frac{\rho N}{2RT} \tag{8}$$

(ρ ist die lineare Dichte der Saite, $\frac{R}{N}$ — die Boltzmannsche Konstante, T — die absolute Temperatur). Q_r hat eine einfache Bedeutung, es ist die Differenz zwischen dem wirklichen Werte von q_r und seinem Werte für die freie Schwingung $\mathfrak{q}_r$:

$$Q_r = q_r - \mathfrak{q}_r. \tag{7'}$$

Setzen wir

$$\frac{Q_r}{\sqrt{B_r}} = \sqrt{\pi}\xi_r, \tag{9}$$

so hat man statt (5)

$$(q_r,\ dq_r) = e^{-\pi\frac{\xi_r^2}{\xi_r'}}\, d\xi_r. \tag{5'}$$

4. Aus (7', 9) hat man $q_r = Q_r + \mathfrak{q}_r = \sqrt{\pi B_r}\,\xi_r + \mathfrak{q}_r$, also (s. 2)

$$u(x,\ t) = \sqrt{\pi}\sum_1^\infty X_r(x)\,\sqrt{B_r}\,\xi_r + \sum_1^\infty X_r(x)\ \mathfrak{q}_r. \tag{10}$$

Für die Wahrscheinlichkeit, dass die Verrückung $u(x,\ t)$ in $(u,\ u + du)$ liegt, hat man *

$$(u,\ du) = \int\ldots\int e^{-\pi\Sigma\frac{\xi_r^2}{\xi_r'}}\, d\xi_1\, d\xi_2 \ldots, \tag{11}$$

das Integral erstreckt über das Gebiet

$$u - \sum X_r(x)\,\mathfrak{q}_r \leqslant \sqrt{\pi}\sum X_r(x)\,\sqrt{B_r}\,\xi_r \geqslant u - \sum X_r(x)\,\mathfrak{q}_r + du. \tag{12}$$

Die orthogonale Transformation

$$\xi_r \longrightarrow \tau_{\mathfrak{r}},\quad \tau_{\mathfrak{l}1} = \frac{u - \sum X_r \mathfrak{q}_r}{\sqrt{\pi\sum X_r^2 B_r}} = \frac{U}{R} \tag{13}$$

liefert ohne Mühe

$$(u,\ du) = \frac{1}{R}\, e^{-\frac{\pi U^2}{R^2}}\, du. \tag{14}$$

Aus (14) folgert man für die Erwartungswerte:

$$\overline{U} = 0,\quad \overline{U^2} = \frac{R^2}{2\pi},$$

also

$$\overline{u(x,\ t)} = \sum X_r(x)\,\mathfrak{q}_r(t) \tag{15}$$

und

$$\overline{[u\ (x,\ t)]^2} = [\,\sum X_r(x)\,\mathfrak{q}_r\ (t)\,]^2 + \frac{1}{2}\sum B_r(t)\ X_r^2(x). \tag{16}$$

Für $t \longrightarrow \infty$ gehen wegen der Dämpfung alle $\mathfrak{q}_r$ gegen Null, B_r geht gegen $\frac{1}{an_r}$ und wir erhalten:

$$\overline{u} = 0,\quad \overline{u^2} = \frac{1}{2a}\sum\frac{X_r^2}{n_r^2} = \frac{RT}{N\rho}\sum\frac{X_r^2}{n_r^2}. \tag{17}$$

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* Wir betrachten zunächst endlich viele Hauptschwingungen und gehe Grenze über.

Ist der Anfangszustand Ruhe in der Gleichgewichtslage, so hat man wieder $q_r = 0$ für alle r und (4)

$$\overline{u} = 0, \quad \overline{u^2} = \frac{1}{2} \sum B_r X_r^2. \tag{18}$$

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PHYSICS

A SYSTEM OF MASSES OF LIGHT ATOMS DEDUCED FROM NUCLEAR REACTIONS ALONE

By L. ISAKOV

(Communicated by S. I. Wawilow, Member of the Academy, 16. VIII. 1935)

Until quite recently, energy balances of nuclear reaction could not be verified otherwise than by means of the mass-spectrograph values of atomic masses. In many cases good accord between the results of direct measurement of energy released and mass-spectrograph data has been realized; yet numerous large discrepancies have been found as well, which necessitated new values of atomic masses to be deduced from the reaction equations themselves (1).

Quite recently Bethe (2) traced the principal source of the discrepancies observed to an error in the mass-spectrograph determinations of the fundamental ratio He : O, and established a better system of atomic masses from a combination of mass-spectrograph values with those deduced from nuclear reactions. Nearly at the same time Aston (3) stated that the mass-spectrograph values in use are in need of revision, but till now he has given no new definitive values.

In this state of things, in the presence of a considerable amount of exact experimental data in the domain of nuclear reactions, it would be of interest to try to use the nuclear reactions themselves for the deduction of a full system of atomic masses. To start with, the domain of the lightest atoms has been selected, up to B (^{11}) inclusive, where we possess the largest amount of reliable data on nuclear reactions, and where, at the same time, great discrepancies in the atomic mass calculations have been found. 19 well established equations of nuclear reactions have been selected, as given below, in Table 1, with references. The values of energy released have been expressed in 10^{-5} atomic mass units throughout; when needed, they have been recalculated from the experimenters' (1) data.

Table 1

Equation	Uncertainty $\times 10^{-5}$ m. u.	Reference	Residuals $\times 10^{-5}$ m. u.
$H^2 = n^1 + H^1 - 0.00210$	$\pm$ 17	(1)	— 2
$H^2 + H^2 = H^3 + H^1 - 0.00426$	2	(5)	4
$H^2 + H^2 = He^3 + n^1 + 0.00279$	21	(6)	1
$Li^6 + n^1 = He^4 + H^3 + 0.00515$	10	(7, 8)	3
$Li^6 + H^1 = He^4 + He^3 + 0.00369$	34	(9)	— 1
$Li^6 + H^2 = 2He^4 + 0.02394$	6	(5)	— 9
$Li^6 + H^2 = Li^7 + H^1 + 0.00508$	10	(10)	20
$Li^7 + H^1 = 2He^4 + 0.01852$	4	(5)	5
$Li^7 + He^4 = B^{10} + n^1 - 0.00300$	30	(11)	— 20
$Be^9 + H^1 = Li^6 + He^4 + 0.00228$	3	(12)	— 1
$Be^9 + H^1 = Be^8 + H^2 + 0.00062$	2	(12)	0
$Be^9 + H^2 = Li^7 + He^4 + 0.00760$	20	(12)	— 5
$Be^9 + H^2 = Be^8 + H^3 + 0.00495$	16	(12)	— 3
$Be^9 + H^2 = B^{10} + n^1 + 0.00445$	33	(13)	— 10
$B^{10} + n^1 = Li^7 + He^4 + 0.00333$	31	(8)	— 13
$B^{10} + H^2 = 3He^4 + 0.01981$	48	(10)	— 10
$B^{10} + H^2 = B^{11} + H^1 + 0.01040$	12	(10, 14)	0
$B^{11} + H^1 = 3He^4 + 0.00900$	60	(12)	25
$B^{11} + H^1 = Be^8 + He^4 + 0.00940$	60	(12)	— 26

In all cases, the uncertainties of the determinations have been recorded (column 3), mostly according to experimenters' statements. The resulting system of equations has been solved by the method of least squares (using successive approximations), the individual equations being weighted in accord with their uncertainties. In this way, a system of atomic mass values has been obtained as given in Table 2. The substitution of these values

Table 2

$n^1 = 1.0081_3$	$He^3 = 3.0170_6$	$Be^8 = 8.0061_9$
$H^1 = 1.0079_9$	$He^4 = 4.0028_9$	$Be^9 = 9.0128_1$
$H^2 = 2.0139_9$	$Li^6 = 6.0156_4$	$B^{10} = 10.0143_2$
$H^3 = 3.0156_9$	$Li^7 = 7.0163_6$	$B^{11} = 11.0099_3$

into equations of Table 1 gives the residuals stated in column 4 of the same table (in units of fifth decimal place). It will be seen from comparison with column 3 that these residuals nowhere exceed 3 units of the 4th decimal place, and in the majority of cases they are well within the calculated uncertainties. The probable errrors of the masses given in Table 2 are within the 5th decimal place; there was no need to compute them, as in the present state of the measurement of energies released in nuclear reactions no real significance can be attributed to these values.

The values obtained for H^1, H^2, He^4, Li^6 and Li^7 are in very good accord thiw mass-spectrograph values, if these are augmented by 1.8 parts in 10 000

(as against 3 in 10 000 given by Bethe) for the effect of error in the ratio He : O. As to the values given by Bethe, their difference from our values is within the probable errors as stated by him (which are rather large—up to 0.001).

The feasibility of an atomic mass system satisfying 19 individual reaction equations to within 1—2 units of the fourth decimal place is certainly of interst. Accordingly, the mass and energy equivalence principle for the elementary transmutation processes can be held as verified within the limits of actual exactitude of transmutation energy determinations.

We have no room here for the numerous inferences that might be made from a system of precise atomic mass values given by Table 2. It would be preferable to make them on a larger basis, when we complete the extension of the present computation to heavier atoms, up to Si^{30} inclusive, where, however, many ol the data available are not so satisfactory, and a critical discussion is needed.

We will mention here just one special problem, which may be fully treated with the aid of the data available—the beryllium problem. Our value for the mass of $Be^8 = 8.0061_9$ or 8.0062 is based on three very reliable determinations by Oliphant ([12]), one of which is in good accord with Kirchner's data ([15]). Thus, our value covers all the secured data for the reactions involving Be^8, using the values for H^1, H^2, H^3 and He^4 which are in accord with the totality of nuclear reactions involving light atoms. We will test the value obtained on another recent result. Bonner and Brubaker ([16]) have observed an emission of neutrons having maximum energy of 13.4 mev. during the bombardment of lithium by deuterons: they interpret this result by the equation $Li^7 + H^2 = Be^8 + n' + 14.3 \pm 0.5$ mev. Computation with our set of data gives for this equation an energy balance of 0.01604 at. wt. units = 15.0 mev.

Thus the value $Be^8 = 8.0062$ may be held as exact within one unit of the fourth decimal place; accordingly, the reaction $Be^8 \rightarrow 2He^4$, if we use our data for He^4 releases only 0.4 mev. of energy, giving rise to two α-particles with ranges of just 0.2 mm. Consequently, the radioactivity of Be^8 may be held as proved, although the possibilities of direct observation are very problematic.

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PHYSIKALISCHE CHEMIE

KINETIK DER ANODENSCHICHTENBILDUNG AUF METALLEN

II. DECKSCHICHTEN VON $PlCl_2$ AUF BLEI

Von L. J. KURTZ

(Vorgelegt von I. V. Grebenščikov, Mitglied der Akademie, 10. VI. 1935)

Als Objekt der vorliegenden Arbeit sind die $PbCl_2$-Schichten, die bei Elektrolyse von Salzsäurelösungen auf der Blei-Anode entstehen, gewählt.

Das Ziel der Arbeit war die Feststellung von Gesetzmässigkeiten im Wachstum der Anodenschichten auf einem Metall, das sich vom in der vorhergehenden Arbeit untersuchten Silber (1) unterscheidet. Die Schlussfolgerungen über die Kinetik des Wachstums der $PbCl_2$-Schichten werden mit den früher in bezug auf die AgCl- und AgBr-Schichten erhaltenen verglichen.

Die Methode der Untersuchung blieb dieselbe. Die Kurven Potential—Zeit wurden mit den an der Oberfläche der Anode sichtbar vorgehenden Veränderungen zusammengestellt. Die Änderung des Anodenpotentials wurde wie früher auf die steigende Abnahme der Stromspannung an dem Widerstande der $PbCl_2$-Schicht zurückgeführt. Die Stromstärke blieb im Laufe des ganzen Versuches streng konstant*.

Als Anode diente der Querschnitt (0.238 cm^2) eines Bleistäbchens. Die leitende Fläche wurde vor jedem Versuch mit einem Rasiermesser erneuert. Als Kathode fungierte ein Platindraht. Die Hauptversuche wurden mit $0.5n$ HCl-Lösungen, gesättigt mit $PbCl_2$, durchgeführt. Die Temperatur bei allen Versuchen war $20.0° \pm 0.05$ C.

Die Polarisationskurve. Zu Beginn der Elektrolyse der genannten Lösungen wächst das Potential der Pb-Anode einige Zeit kaum merklich, dann steigt es sprungweise worauf bald eine lineare Zunahme des Potentials mit der Zeit sich einstellt.

Durch visuelle Beobachtung wurde festgestellt, dass der erste Teil der Kurve der Verbreitung von Inselchen des kristallinischen $PbCl_2$ über die Oberfläche der Anode hin entspricht. Im Moment t_B, der dem Sprung des Potentials entspricht, war schon die Oberfläche der Anode gänzlich von einer dünnen Schicht festen Salzes überdeckt. Die weitere lineare Änderung des Potentials entspricht der Zunahme der Schichtendicke.

Die zeitliche Veränderung des Potentials der Pb-Anode in $0.5n$ HCl, gesättigt mit $PbCl_2$ bei einer Stromdichte von 0.8 m.A·cm $^{-2}$ ist in der Tabelle 1 veranschaulicht. Die Zeit t_B, der Sprung des Potentials $\Delta\pi_B$ zum Zeitpunkt t_B und die weitere Änderung des Potentials $d\pi/dt$, die bei verschiedenen Stromdichten beobachtet wurde, sind in der Tabelle 2 angeführt.

* Das Schema der Einschaltung der Zelle in den Stromkreis von streng konstanter Stärke ist der Arbeit von A. G. Samarcev und K. S. Evstropiev entnommen (2).

Aus ihr kann man ersehen, dass der erwähnte Sprung bei geringen Stromdichten bedeutend später erfolgt, aber in allen Fällen nähert er sich 0.5 Volt und wird durch den bedeutenden Widerstand der zum Zeitpunkt t_B schon zusammengeschlossenen Inselchen des $PbCl_2$ hervorgerufen*.

Tabelle 1

Vergleich zweier Schemen für den Mechanismus der Bedeckung der Pb-Anode mit einer $PbCl_2$-Schicht
$i = 0.8$ mA·cm^{-2}

Zeit		Schema A			Schema B			
Min.	Sec.	δ μ	$(1-F)$ cm²/cm²	$\Delta\pi_{berechnet}$ mV	$\Delta\pi_{gefunden}$ mV	$(1-F)$ cm²/cm²	δ μ	i_p %
—	30	0.79	$93\cdot10^{-2}$	0.010	0	—	—	—
1	30	0.79	78	0.012	0.05	$4.3\cdot10^{-2}$	0.18	100
2	—	0.79	70	0.013	0.10	2.8	0.24	100
3	—	0.79	55	0.017	0.35	1.2	0.35	100
5	—	0.79	$260\cdot10^{-3}$	0.036	1.6	$4.3\cdot10^{-3}$	0.59	100
6	—	0.79	100	0.093	3.4	2.4	0.70	100
6	30	0.79	40	0.230	6.0	1.5	0.76	100
6	45	0.79	$1.3\cdot10^{-5}$	465	465	$1.3\cdot10^{-5}$	0.79	65

Weiterhin wächst das Potential linear an, mit 115 mV pro Minute.

Tabelle 2

Angaben über $PbCl_2$-Schichten auf einer Pb-Anode in 0.5n HCl, gesättigt mit $PbCl_2$. Durchschnittswerte mehrerer Bestimmungen für jede Stromdichte: t_B—Zeit der vollständigen Überdeckung, δ_B—Schichtendicke, $\Delta\pi_B$—Änderung des Anodenpotentials, aus welchem die Porosität der Schicht $(1-F_B)$ berechnet ist, i_p—Teil des Stromes, der durch den Elektrolyten in den Poren geleitet wird, $d\pi/dt$—weitere Änderung des Potentials, aus der die spezifische elektrische Leitfähigkeit $\varkappa$ der Schicht berechnet ist.

i mA·cm^{-2}	t_B Min.	Zum Zeitpunkt t_B: δ μ	$\Delta\pi_B$ mV	$(1-F_B)$ cm²/cm²	i_p %	Beim weiteren Tiefenwachstum: $d\pi/dt$ mV/Min.	$\varkappa\cdot10^7$ $\Omega^{-1}\cdot$cm^{-1}
0.2	62	1.82	430	$0.77\cdot10^{-5}$	61	26.5	0.25
0.4	23	1.36	466	1.11	64	56.7	0.43
0.8	6.6	0.77	465	1.28	65	115	0.82
1.6	2.0	0.46	480	1.47	68	337	1.08
3.1	1.0	0.47	825	1.72	67	1015	1.37

Die Dicke δ_B der Schicht zum Zeitpunkt t_B, die aus der in der Zeit t_B durchgeflossenen Elektrizitätsmenge berechnet wurde, nimmt mit dem Steigen der Stromdichte merklich ab (siehe Tabelle 1), zuerst schnell, dann langsamer (1.82—0.47μ).

Prozess der Überdeckung der Pb-Anode mit einer $PbCl_2$-Schicht. Wir haben die Änderung des Anodenpotentials für diesen Überdeckungsprozess aus dem Flächenbedeckungsgesetz W. J.

* Auf das Fehlen bei diesen Versuchen von chemischer Polarization des Bleis weist eine Reihe von Überlegungen hin, die in der Dissertation von L. J. Kurtz «Zur Frage über die anodische Passivität der Metalle» angeführt sind. Sieh auch [3] und [4].

Müllers [5] berechnet, d. h., wir haben angenommen, dass der Prozess des allmählichen Zusammenschliessens der Inselchen bei der konstanten Dicke δ_B vor sich geht. Die Schicht $PbCl_2$ ist als absolut nicht leitend angenommen und die Anodenschicht des Elektrolyts zwischen den Inselchen des festen $PbCl_2$ wird als gesättigt mit einer Lösung von $PbCl_2$ ($\varkappa = 6.8 \cdot 10^{-3}$) angenommen.

Der freie Teil der Anodenoberfläche $(1-F)$ verringert sich proportional mit der Zeit. Die Änderung des Potentials $\Delta\pi$ beträgt dann:

$$\Delta\pi = \frac{\delta_B \cdot i}{\varkappa_p - (1-F)}. \qquad (1)$$

Das Ergebnis der Berechnung (Schema A, Tabelle 1) für den Versuch bei 0.8 $mA \cdot cm^{-2}$ weicht bedeutend von der tatsächlich beobachteten Änderung des Potentials ab.

Nimmt man hingegen an, dass die Dicke der sich zusammenschliessenden Inselchen des $PbCl_2$ gleichzeitig mit ihrer Verbreitung über die Oberfläche der Anode wächst, und berücksichtigt man den durch die Schicht des festen $PbCl_2$ geleiteten Teil des Stromes i_s, so erhält man vier Gleichungen mit vier Unbekannten: $\Delta\pi$, F, i_p und i_s:*

$$K \cdot i \cdot t = \delta \cdot F \cdot d; \qquad (2)$$

$$i = i_p + i_s; \qquad (3)$$

$$\Delta\pi = \frac{\delta \cdot i_p}{\varkappa_p \cdot (1-F)} = \frac{\delta \cdot i_s}{\varkappa_s \cdot F}, \qquad (4)$$

wo K das elektrochemische Äquivalent des $PbCl_2$, i die mittlere Stromdichte an der Anode, δ und F, resp., die Dicke und die Fläche der $PbCl_2$-Schicht, d das spezifische Gewicht des $PbCl_2$, $\Delta\pi$ die gemessene Änderung des Potentials bedeuten.

Bei der Lösung dieses Systems von Gleichungen finden wir δ und F der $PbCl_2$-Schicht für eine beliebige Zeit t. In der Tabelle 1 (Schema B) sind die Ergebnisse der Berechnung für 0.8 $m \cdot A \cdot cm^{-2}$ angeführt. Aus der Tabelle ist ersichtlich, dass der grösste Teil (95.7%) der Anodenoberfläche schon im Laufe der ersten 1.5 Min. überdeckt wird. Die mittlere Dicke der Schicht ist zu dieser Zeit nur 0.18 μ. Darauf werden die $PbCl_2$-Inselchen dicker, aber setzen gleichzeitig ihre Verbreitung über die Anodenoberfläche fort. Zum Zeitpunkt t_B schliessen sie sich in eine fast ununterbrochene Schicht zusammen, die weiterhin vorwiegend in die Tiefe wachsen muss.

Tiefenwachstum der Schicht. Nimmt man an, dass sich die ganze Fläche der Schicht verdickt, so führt die tatsächliche Änderung des Potentials zur Schlussfolgerung, dass das Wachsen der Schicht in die Dicke von einer geringfügigen Abnahme des Porositätgrades begleitet wird.

Nimmt man aber mit W. J. Müller [5] an, dass die Gesamtfläche aller Poren konstant bleibt, so folgt aus dem Gange der Kurve $\pi - t$ und zwar in Übereinstimmung mit den Vorstellungen W. J. Müllers, dass nicht die ganze Fläche der Schicht dicker wird, sondern nur ein gewisser, die Poren umgebender Teil (12—39%). Die Schwierigkeit der Deutung der erhaltenen Kurven wird dadurch bedingt, dass an dem betrachteten Prozess zweifels-ohne solche Faktoren beteiligt sind, wie Elektroosmose und Temperaturzunahme in den Poren der Schicht. Das erhaltene Versuchsmaterial

* Die spezifische elektrische Leitfähigkeit des Elektrolyts $\varkappa_p$ ist wie früher als $6.8 \cdot 10^{-3}$ angenommen. Die elektrische Leitfähigkeit der festen Schicht $\varkappa_s$ ist $4.46 \cdot 10^{-8}$. Sie wurde nach der Formel von W. Seith [6] berechnet.

reicht nicht aus, um die Frage über den Mechanismus des Tiefenwachstums der Schicht endgültig zu entscheiden.

Die Porosität $(1-F_B)$ der $PbCl_2$-Schicht zum Zeitpunkt t_B ($0.77—1.72 \cdot 10^{-5}$ cm² auf 1 cm² der Anode), die aus dem Sprung des Potentials $\Delta\pi_B$ berechnet wird (nach den Gleichungen 2—4), nimmt, wie aus Tabelle 2 ersichtlich, mit der Stromdichte zu.

Die elektrische Leitfähigkeit der $PbCl_2$-Schicht (Durchschnittswert für die gesamte Schicht) wurde aus der Neigung des geradlinigen Teils der Kurve Potential—Zeit berechnet. Sie nimmt mit dem Steigen der Stromdichte zu (Tabelle 2), aber sogar bei 3.1 mA·cm^{-2} ($13.7 \cdot 10^{-8}$) ist sie nur 3 mal grösser als die $\varkappa$ des festen Salzes ($4.5 \cdot 10^{-8}$). Dieses bestätigt die sehr geringe Porosität der $PbCl_2$-Schichten.

Schlussfolgerungen

1. Bei Elektrolyse der 0.5 *n* HCl-Lösung, gesättigt mit $PbCl_2$, wird die Bleianode mit Inselchen des kristallinischen $PbCl_2$ bedeckt. Sie verbreiten sich schnell über die Oberfläche der Anode und beginnen dann gleichzeitig mit ihrer seitlichen Ausbreitung auch in die Dicke zu wachsen.

2. Zum Zeitpunkt t_B beträgt der nichtbedeckte Teil der Anode ungefähr 10^{-5} cm² auf 1 cm². In der Arbeit werden zwei mögliche Schemen des weiteren Anwachsens der Schicht in die Dicke betrachtet.

3. Die Dicke der Schicht (1.82—0.45 μ) nimmt zum Zeitpunkt t_B mit dem Steigen der Stromdichte ab, umgekehrt aber wächst die Porosität (ähnlich wie bei den AgX-Schichten).

4. Die elektrische Leitfähigkeit der $PbCl_2$-Schichten steigt mit der Zunahme der Stromdichte (ähnlich wie bei den AgX-Schichten). Der Vergleich der $\varkappa$ der $PbCl_2$-Schichten ($2.5—13.7 \cdot 10^{-8}$) mit derjenigen des gepressten $PbCl_2$-Salzes ($4.5 \cdot 10^{-8}$) bestätigt die geringe Porosität der untersuchten Schichten (grundliegender Unterschied von den AgX-Schichten).

5. Die Kinetik des Wachstums der $PbCl_2$-Schichten bietet grosse Analogie mit derjenigen der von uns früher [1] untersuchten AgX-Schichten. Der Unterschied in den Polarisationskurven des Pb und Ag (Ausfall des Potentialssprunges der Ag-Anode zum Zeitpunkt t_B) wird durch die bedeutende Porosität der AgX-Schichten bedingt.

Die Arbeit ist im chemischen Sektor des staatlichen optischen Instituts in Leningrad ausgeführt.

Zum Schluss spreche ich meinen tiefsten Dank A. G. Samarcev für die Anweisung, des Themas und für seine ausserordentlich wertvolle und aufmerksame Leitung aus, ebenso auch I. V. Grebenščikov, dem Mitglied der Akademie, für sein der Arbeit beständig entgegengebrachtes Interesse.

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GENETICS

A MORPHOLOGICAL ANALYSIS OF CHROMOSOMES IN MAN

By A. H. ANDRES and M. S. NAVASHIN

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In the chromosme set of man we can distinguish morphologically in the first division of maturation only individualized sex-chromosomes of the heterogametic sex. The sex-chromosomes of the homogametic sex, as well as the autosomes of both sexes, have not been hitherto individually distinguished. The majority of investigators limit themselves to a general description of single components of the set [Winiwarter (1), Winiwarter and Oguma (2), K. Oguma (3), T. Kemp (4), O. Minouchi and T. Otha (5)]. T. Painter (6,7) in addition to the sex-chromosomes finds it possible to distinguish one pair of largest heterobrachial autosomes (consisting of unequal arms), which he calls *A* chromosomes. A more detailed classification of individual components of the set was given by P. Shiwago and A. Andres (8), who distinguished three groups of autosomes; the 1st consists of 7—8 largest elements, some with a subterminal and some with a median attachment of the spindle fibres. Among the latter type, two horseshoe like pairs, almost equal in size, can be readily distinguished. The 2nd group consists of eleven mediumsized mostly rod-shaped chromosomes with terminal attachment, and, finally, the 3rd group includes 4—5 smaller elements appearing as short rods. In the present paper an attempt is made to analyse further the chromosomes of man and to differentiate morphologically distinguishable pairs. As material we used: 1) ovaries of 4—4.5 months old embryos, 2) testis of two Russians (25 and 35 years old) fixed by the method of Painter, sections 15 μ thick, stained by Newton's method as modified by M. Navashin, 3) scrapes from the mucous membrane of the uterus of a woman 32 years old; fixed in the same manner, stained by the method of Michaelis, 4) the amnion of a foetus 8—9 weeks old, investigated *in toto*, fixed with a strong Flemming's solution and stained by the method of Michaelis, 5) a culture of an embryonic lung, 6) a culture of an embryonal mesenchyme *in vitro*, fixed with a Flemming's solution with a reduced acetic acid and osmium content and treated by the method of Feulgen, 7) a culture *in vitro* of the skin of a 60 years old man

affected with sarcoma Kaposi: fixed by the method of Zenker, stained with the hematoxylin of Delafield. The cultures *in vitro* were studied *in toto*.

The cultures of the tissues were made by H. A. Berlin, T. M. Černožukova, and L. P. Lipčina. Moreover, we used testis of a Japanese kindly sent to us by O. Minouchi from the material of his work in 1934. The authors wish to thank all these persons for their assistance.

We have studied in total 34 orthoploid chromosome sets. In all we succeeded in distinguishing individually 10 largest autosome pairs. The first pair is represented by large U-shaped chromosomes with somewhat unequal arms, one of the latter being about $^1/_4$ longer than the other; therefore the attachment of the spindle fibre is a subterminal one. The second pair consists of two somewhat smaller J-like chromosomes, one arm being twice as long as the other. The spindle-fibre attachment lies about $^1/_3$ of the length from the proximal end. The third pair is only a little smaller than the second, U-shaped, with a median attachment of the fibre. The fourth, fifth, sixth, and seventh pairs form a group of elements similar in shape and not always easily distinguishable.

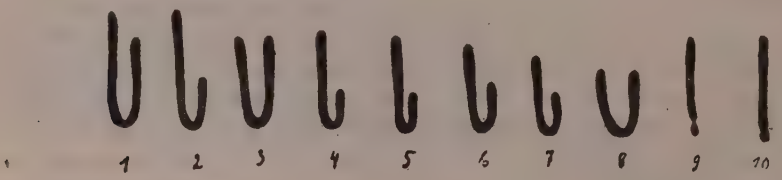

Fig. 1. Diagrammatic drawing of the first ten pairs of autosomes of man.

In the components of the 4th and 5th pairs the shorter arm is always about $^1/_3$ of the longer, but the chromosomes of the 4th pair are a little longer than those of the 5th. The 6th pair corresponds in length to the 5th, but the shorter arm of its elements is comparatively longer than in the 5th, being almost $^1/_2$ of the long one. The 7th pair consists of similar components, but they are somewhat shorter than the elements of the 6th. The 8th pair consists of medium-sized U-shaped elements with equal arms and a median attachment, their length being half that of the 1st pair. The 9th pair consists of rod-shaped chromosomes with a bean-shaped appendix (trabant) about $^1/_{10}$ of the length of the chromosome itself; they aproach in length the 8th pair. Sometimes the satellite is retruded, and then these chromosomes appear rod-shaped with a subterminal attachment, almost undistinguishable from those belonging to the 10th pair.

In measuring the length of the chromosomes, we confined ourselves to measurments on drawings of individually distinguishable chromosomes, by selecting those lying stritly in one plane. The length of the chromosomes in the cells of various tissues appeared to be different. The longest chromosomes belong to tissues growing *in vitro*, the shortest ones to ovogonia in

sectioned embryonic material. The results of measurements are tabulated below, the lengths being indicated in μ*.

Nos	Spermatogonia		Ovogonia	Epithelium of the glands of the mucous of the uterus	Amnion	Mesenchyme of an embryonic lung *in vitro*	Embryonal fibroblast *in vitro*	Skin epithelium of an adult *in vitro* (affected with sarcoma Kaposi)
	Russians	Japanese						
1	5.3—6.6	6.3—7.2	4.0—6.0	6.6—6.8	6.0—6.4	10.0—10.8	10.0	9.7—10.3
2	4.4—5.3	5.5—6.1	3.4—4.8	—	4.7	8.4—10.0	7.8—9.0	10.0—10.3
3	3.6—4.2	5.0—6.4	2.7—4.2	—	4.8	8.4	5.3—5.5	7.3— 9.0
4	3.4—4.4	3.4—4.0	3.0—4.0	5.3	—	6.3—7.2	6.3	6.0
5	3.1—4.0	4.0—4.4	2.8—3.3	4.0	—	5.0—6.8	5.6	—
6	3.4—4.4	3.6—4.0	2.9—3.6	—	—	5.6—6.4	—	—
7	3.3—4.0	-	—	—	—	—	—	—
8	2.8—3.3	3.0—3.3	2.5—3.4	—	—	—	—	—
9	-	—	—	3.4—4.4	—	—	—	—
10	2.5—2.8	—	2.3	—	—	5.0—7.8	—	—

Further, a comparison of the length of six autosome pairs in the spermatogonia of a Japanese and Russians shows that the first three pairs in the Japanese are considerably longer (1st and 2nd 20 p. c. and 3rd 50 p. c.), while the lengths of the 4th, 6th, and 8th coincide. Comparing our data to those of Oguma (3) on the length of some large chromosomes in the spermatogonia of a Japanese and a Belgian and taking also into consideration the observation of Painter (6,7) according to whom the largest chromosome in the Negro represents a J-shaped element (*A* chromosome according to Painter) corresponding to our 2nd chromosome** we can assume the possibility of racial variations of the caryotype in men, at least with regard to the largest autosomes. Finally, analysing the drawings contained in the works by Winiwarter (1), Painter (6,7), Oguma and Kichara (9), Winiwarter and Oguma (2), T. Kemp (4), Evans and Sweezy (10), Oguma(3), and Minouchi and Otha (5), we consider it

* This table shows a considerable phenotypical variation in the length of separate chromosomes; it obviously is beyond limits of variations which might be caused by differences of technique.

** In some of the Painter's drawings the *A* chromosome is rather horses-hoe-like and possesses unequal arms.

possible to distinguish in them some of the autosome pairs described by us; we must emphasize, however, that it is not always possible to find in the illustrations of the above writers all the 10 pairs described by us.

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BIOCHEMISTRY

A COLORIMETRIC METHOD FOR THE QUANTITATIVE DETERMINATION OF GLUCOSE AND LAEVULOSE BY THEIR OSAZONE

By V. S. BUTKEVIČ (Butkevitsch), Corresponding Member of the Academy, and M. S. GAJEVSKAJA

The usual methods of quantitative determination of sugars are based on their reducing power. These methods do not always guarantee correct results, inasmuch as the substrata subjected to analysis along with the sugars may contain other substances that are also capable of reducing. Consequently, in the quantitative determination of sugars in natural substrata it is desireable, as a control for the results obtained by the usual methods, also to utilize methods based on other reactions that are characteristic for sugar. The colorimetric method based on the utilization of the yellow colour of glucosazone, is one of the attempts in this direction. This method was first proposed by Dische [1] and not long ago more nearly perfected in its application to the determination of glucose by Herzfeld [2]. According to the data of the latter writer, his method gives satisfactory results for glucose and can be succesfully utilized for its determination even in the presence of other reducing substances that do not give the corresponding osazone. However, Demmel[3], on trying out the method with glucose, did not always obtain coinciding results and, in certain cases, the deviation from the actual quantity was as much as 25 p. c.

Tests of Herzfeld's method that we have carried out have shown that by making certain alterations in it satisfactory results may be obtained in the analysis of substrata containing not only glucose but also laevulose.

In our tests of the method, we used as a standard the solution of Folin, recommended by Herzfeld for the colorimetric determination of glucosazone, namely, a 0.0245 p. c. solution of potassium bichromate. This solution, according to Herzfeld, ought by its colour to correspond, in his method of determining glucose, to 1.45 mg of glucose in 100 cm^3 of the solution of glucosazone under investigation.

However, when we followed the directions of Herzfeld exactly and used his coefficient, we obtained for glucose quantities that were less than its actual content in the solution analysed. This discrepancy disappeared when the time of heating the glucose solution with phenylhydrazine was prolonged to 1.5 hours instead of 1 hour as recommended by the author. Our experiments further showed that filtration of the solution after heating with phenylhydrazine, as recommended by the author, might better be omitted altogether, the accuracy of the analysis being thus essentially raised. Furthermore, instead of covering the solution with paraffin oil for the time it stood after being heated with phenylhydrazine, we covered it with solid paraffine, which

proved to be more convenient. The influence on the results of the quantity of phenylhydrazine used in obtaining osazone and of the quantity of water used in washing it was also elucidated by suitable experiments.

On the basis of our findings, we were able to establish the following method, which gives satisfactory and sufficiently constant results for glucose.

Into a test tube containing 10 cm^3 of the solution to be analysed, the latter containing from 3 to 8 mg of glucose, is introduced 1.5 grams of sodium acetate and 1 gram of phenylhydrazine hydrochloride. Its contents being stirred with a glass rod having a flattened end, the test tube is heated for 1.5 hours in a boiling water bath. Then the surface of the tube, together with the glass rod, is covered with melted paraffin, and the test tube is left over night so that the osazone formed might crystallize. On the following day, the paraffine stopper, together with the glass rod, is lifted out and transferred with the osazone precipitate to the Schott glass filter No 2g. The whole is washed by 50 cm^3 of ice water, and after that the precipitate is dissolved in alcohol acidulated with hydrochloric acid (100 cm^3 of alcohol per 1 cm^3 of concentrated HCl). The solution is brought to a definite volume (100—200 cm^3) and colorimetrized by means of the standard potassium bichromate solution mentioned above. The quantity of glucose is calculated by means of Herzfeld's coefficient (1.45). In order to obtain satisfactory results by this method of glucose determination, it is necessary to use, as Herzfeld also points out, phenylhydrazine hydrochloride prepared by the method recommended by him [2] or else well purified by recrystallization [4].

That this method, modified as shown above, can be successfully used for the determination of glucose is evident from the summary given in Table 1 of the results that we obtained.

Table 1

Amount of Glucose in mg

Taken	Found	Difference in p. c. of amount taken	Taken	Found	Difference in p. c. of amount taken
5.00	5.03	+ 0.6	4.58	4.54	— 0.8
5.00	5.02	+ 0.5	3.98	3.97	— 0.2
5.00	5.13	+ 2.6	3.98	3.90	— 2.0
3.98	4.02	+ 1.0	3.80	3.72	— 2.1
3.98	4.04	+ 1.5	5.73	5.59	— 2.4
3.08	3.09	+ 0.3	5.23	5.11	— 2.2

Average: taken 4.445 mg, found 4.430 mg, difference 0.34 p. c.

The discrepancy, as compared with the actual quantity of glucose, does not exceed ±2.5 p. c.

Experiments with different durations of heating showed that the coefficient given by Herzfeld for the calculation of the quantity of glucose corresponds only to a particular length of the heating period (according to our experiments 1.5 hours). On increasing the duration of heating, the quantities obtained by the given coefficient also increase, attaining a maximum with from 5 to 7 hours heating and exceeding approximately twice the results obtained from 1.5 hours. This is due to the fact that the conversion of glucose into osazone is only about half finished during 1.5 hours heating and is

completed after 5 to 7 hours. In the case of laevulose, the formation of osazone as is well known, is considerably easier than in the case of glucose, and it is completed after 1.5 hours of heating with phenylhydrazine. Consequently, with this duration of heating, Herzfeld's coefficient gives for laevulose quantities that are approximately twice the actual content of the solution analysed. This is apparent from the data in Table 2.

Table 2

Amount of Sugar in mg

Duration of heating (hours)	1.5	1.5	5	5	7	7	9	9
Taken	5 mg of glucose or laevulose							
Found for glucose	4.64	5.03	8.58	8.64	10.15	9.86	9.19	9.13
Found for laevulose	10.09	10.84	10.70	10.35	—	—	—	—

Thus, in applying this method, in its present modification, to the determination of glucose, correct results can be obtained only through strict observance of the duration of heating with phenylhydrazine, during which about half the glucose passes into osazone. But since laevulose passes entirely into osazone during that length of heating, the coefficient ought to be halved. In Table 3 are shown the results ascertained for laevulose after 1.5 hours heating and for a coefficient only half as great (0.725).

Table 3

Amount of Laevulose in mg

Taken	5	5	5	5	8	8
Found	4.80	5.07	5.22	5.26	8.35	8.40

The quantities of laevulose and glucose ascertained through colorimetrization of their osazones are confirmed also by means of a weight determination of the osazones forming during a 1.5 hours heating period. Solutions of glucose and laevulose containing 5 mg of sugar each, after being heated for 1.5 hours with phenylhydrazine without any covering of paraffin, were placed overnight into an exsicator in which the air was replaced by ether vapours. On the following day, the precipitate of osazone was filtered in a glass filter, washed, dried at 60° over sulphuric acid in a vacuum exsicator and weighed. The results are shown in Table 4.

Table 4

Amount of Osazone from 5 mg of Sugar

Sugar taken		Obtained (mg)	Average (mg)	In p. c. of the theoretical yield
Glucose	1	4.5	4.9	49.2
	2	5.3		
Laevulose	1	9.0	9.4	94.5
	2	9.8		

The amount of ozazone in the case of laevulose reaches almost the theoretical quantity and is twice higher than for glucose.

Thus, when glucose and laevulose are heated for 1.5 hours, the coefficients are different for the two substances, since the reaction with the former runs to half completion and that with the latter to completion. Hence arise difficulties in the analysis of substrata that contain both glucose and laevulose. These difficulties may be circumvented only by carrying the reaction with glucose to completion, that is, by prolonging heating, in accordance with the data brought forward above, from 5 to 7 hours. Experiments carried out along this line have shown that such a method of joint determination of glucose and laevulose can, indeed, really be used, but that the accuracy of determination suffers somewhat, especially in the case of glucose, which, when subjected to prolonged heating, undergoes a certain amount of resinification. When the heating was prolonged to 5 hours and the calculation was made with a coefficient lessened to half (0.725), results shown in Table 5 were obtained for solutions containing various amounts of glucose and laevulose.

Table 5

Amount taken (mg)		Amount of sugar determined by the colorimetric method	
Glucose	Laevulose	mg	p. c. of sugar taken
4	1	4.44	88.8
2.5	2.5	5.07	101.4
1	4	5.20	104.0

A considerable discrepancy, exceeding 10%, is found only in the solution with a strong predominance of glucose.

Deductions

This method, based on the colorimetric determination of osazones, can be applied successfully to the quantitative determination of both glucose and laevulose. According to our experiments, the coefficient of Herzfeld corresponds for glucose to 1.5 hours of heating with phenylhydrazine. It ought to be halved for the same duration of heating in the case of laevulose. For laevulose, under these conditions, the yield of osazone is twice as great as for glucose and is close to the maximum theoretical value.

When glucose and laevulose are determined together, an equalization of the yieldsof osazone can be obtained by increasing the duration of heating with phenylhydrazine to 5—7 hours and by decreasing the coefficient of Herzfeld by one half.

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BIOCHEMISTRY

AUTOCLAVE SPLITTING OF PROTEIN BY MEANS OF ABSOLUTE METHYL ALCOHOL

By V. S. SADIKOV and V. A. VADOVA

(Communicated by A. A. Richter, Member of the Academy, 17. IV. 1935)

The heating of protein substances in an autoclave at 180° with absolute methyl alcohol results in an incomplete splitting of the protein with the formation of products soluble in alcohol; these are mainly substances of the type of cyclopeptides (1).

The task we set before us was to isolate some individual compounds from an autoclave alcoholysate for the purpose of settling the question whether an autoclave alcoholysis gives the same products as autoclave hydrolysis.

The conditions of the experiment were as follows: 1) the protein of blood serum was dried at 120°; 2) the protein was mixed with absolute methanol in the ratio of 1 to 5 by weight; 3) the mixture was heated for 3 hours at 180° in an Ipatjev's autoclave, the pressure attaining 50—60 atm. The time needed for heating and cooling the autoclave was nearly 4 hours.

2000 g of protein were subjected to the treatment described above. The alcoholysate dissolved completely in alcohol; there was no solid phase.

The alcoholysate contained free ammonia.

The total nitrogen content in the dry residue formed 12.35 per cent, i. e. 15 per cent less than in the initial protein; the loss is to be accounted for as due to the volatilization of nitrogen. The amount of nitrogen removed from the alcoholysate with MgO by Folin's method formed 13.7 per cent of the total protein nitrogen; the aminonitrogen detectable in the alcoholysate by van Slyke's method formed 8.7 per cent of the total protein nitrogen.

Thus, the content of non-Slyke's nitrogen in the alcoholysate, which may be regarded as a cyclic aminonitrogen and partially as diaminonitrogen, attained 62.6 per cent of the total protein nitrogen.

At 180° methanol acts upon protein nearly in the same way as caustic alkali, causing an abundant yield of ammonia, which forms 28.7 per cent of the total protein nitrogen.

The protein alcoholysate free from alcohol and ammonia was treated with water and separeted into 2 fractions: 1) soluble in water, 2) insoluble in water. Both fractions were extracted with ether. From the ether part of the water soluble fraction we isolated a crystalline substance, which was subjected to a careful investigation. After multiple recrystallizations from ethyl alcohol, we obtained a compound with a constant melting point 275.5°C. This compound is soluble in boiling absolute ethyl alcohol up to 3.86 per cent. It is insoluble in water and benzene, scarcely soluble in ether and methanol, easily soluble in ice-cold acetic acid and chloroform.

The analysis of this compound yielded the following results:

Found: C = 62.26 p. c.; H = 9.12 p. c.; N = 13.18 p. c.; molecular weight = 211.
Calculated for $C_{11}H_{20}N_2O_2$: C = 62.21 p. c.; H = 9.50 p. c.; N = 13.21 p. c.; molecular weight = 212.

The compound $C_{11}H_{20}N_2O_2$ contains no aminonitrogen, but on hydrolysis the whole nitrogen can be detected by van Slyke's method. Thus, the substance under investigation is a cyclopeptide containing no proline.

In order to elucidate the nature of aminoacyles forming the cyclopeptide $C_{11}H_{20}N_2O_2$, 0.4994 g of the substance were subjected to a splitting with boiling 25 per cent. HCl during 36 hours. After a complete elimination of HCl from the obtained hydrolysate, the latter was treated with $CuCO_3$, and the resulting copper salts of amino-acids were separated into two parts: easily soluble in water an scarcely soluble in water.

It was found that the first part is easily soluble in methyl alcohol.

An analysis of the copper salts of amino-acids from the first and the second parts yielded the following results:

Table 1.

Content in percentages	I fraction	Leucine	II fraction	Valine
Cu	19.66	19.64	21.37	21.49
N	8.84	8.67	9.40	9.50

Thus the cyclopeptide $C_{11}H_{20}N_2O_2$ is a cycloleucylevaline. Since it manifests no rotation, its structure is characterized by the absence of asymmetric carbons due to allomerization. The structure of the cyclopeptide in question may be represented as follows:

$$C_3H_7 - C = C(OH) - NH$$
$$\quad\quad\quad

The ether fraction of the soluble part contains also other cyclopeptides, which are being investigated.

The ether extract from the part insoluble in water is a syrup containing 8.35 per cent nitrogen with regard to the dry substance of the extract. Aminonitrogen and amide nitrogen are absent in this extract.

After a 36 hour open hydrolysis with 20 per cent. H_2SO_4, the total nitrogen content amounted to 6.22 per cent. No amide nitrogen formed, while amino-nitrogen constituted 57 per cent of the total nitrogen of the hydrolysate.

The solid mass resulting from the hydrolysis was further hydrolysed with 20 per cent. H_2SO_4 during 12 hours more.

The second hydrolysate gave 222 per cent nitrogen, i. e., together with the first, 8.44 per cent nitrogen corresponding to 8.33 per cent of the ether extract from the insoluble part.

The above described treatment of the autoclavolysate did not effect a complete separation of the substance into a water soluble and a water insoluble fractions and did not isolate a fraction that gave no aminonitrogen on hydrolysis, as was the case in the autoclave splitting of protein with ethanol.

In comparing the different methods of blood albumin autoclave splitting with regard to certain indices of the depth of degradation, we find great differences in the chemical composition of the corresponding lysates, as will be seen from the following table:

Table 2

Different Methods of Blood Albumin Autoclave Splitting

	Hydrolysates		Alcoholysates	
	Acid H_2SO_4	Carbonate K_2CO_3	Ethanolysate C_2H_5OH 97 p. c.	Methanolysate CH_3OH 100 p. c.
1) Loss of protein nitrogen (percentages of total nitrogen)	15.0	20.1	19.0	15.0
2) Amino-nitrogen content in the lysate after van Slyke (percentages of total nitrogen)	27.0	20.0	29.0	8.7
3) Ammonium nitrogen content in the lysate after Folin (percentages of total nitrogen)	25.0	25.0	2.0	13.7
4) Sum total of cyclically combined imino-nitrogen and diamino-nitrogen	48.0	34.0	57.0	62.6

The methanolysate differs from other autoclavolysates in a low amino-nitrogen and ammonium nitrogen content, as compared with hydrolysates and the ethanolysate methanolysis results in the highest yields of cyclic compounds.

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PLANT PHYSIOLOGY

DETERMINATION OF FROST RESISTANCE OF WINTER WHEAT AND RYE IN GRAIN.

By M. I. SALTYKOVSKIJ.

(Communicated by A. A. Richter, Member of the Academy, 14. VIII. 1935)

The selection of winter wheats and ryes for winter hardiness calls for a special method that would answer the following requirements: 1) it must ensure so high a yield as to admit of mass determinations of resistance to frost of various varieties; 2) it must ensure simplicity and rapidity of determination; 3) it must permit the selection of frost resisting varieties from populations and hybrid mixtures.

Especially important is the method of choosing winterhardy forms out of the material available for selection, and it is just this method that has up to the present been most imperfectly worked out. The questions involved would be solved best by determining the resistance to frost of winter cultures in grain; in 1932, we therefore set ourselves the task of developing a method for determining the resistance to frost of winter cultures in grain.

The work done in hardening plants to low temperatures had shown that during the process of hardening green plants, the latter accumulate large reserves of sugar. During the germination of the seed, the starch of the endosperm is converted into sugar. If germination is retarded by lowering the temperature, the seed accumulates a fairly large amount of sugar. We took advantage of this fact to harden soaked and sprouting grains of wheat and rye, i. e. to increase their resistance to frost.

The experiments of 1932 showed that a soaked and sprouting grain can, after having been kept for about 40 days at temperatures of $+6°$ to $0°$, become inured to temperatures of down to $-12°$. No further increase of frost resistance can be achieved by this treatment. For instance, in freezing at $-11°$, we obtained the following percentages of germination: winter wheat 0118—45 p. c.; Ukrainka—43 p. c., Schroeder—9 p. c., while a temperature of $-14°$ gave 1, 5 and 0° p. c. respectively.

At the Second All-Union Conference on the Winter Hardiness of Plants held at Odessa in 1933, I. I. Tumanov made a report on two phases of hardening of winter varieties. The first phase takes place at temperature of about $+8°$ down to 0°. During that phase, the plant needs light. At that stage of hardening, the plant lays in a reserve of sugar. The second stage, the second phase, of hardening follows the first and requires temperatures below zero, i. e. about -1 to $-3°$, no light being needed. The first phase of plant hardening brings the frost resistance of winter wheat up to about $-12°$; the second phase may result in a further considerable increase. The experiments made by E. Saprighina in 1934 fully confirmed the statement of

I. I. Tumanov to the effect that green plants cannot enter upon the second phase of hardening to low temperatures unless they have passed through the first.

Some varieties of winter wheats are comparatively better hardened in the first than in the second phase; with others the contrary is the case, while some others are well hardened both in the first and in the second phase (P. G. Brokert and I. I. Tumanov). The most frost-resistant kinds are well hardened at both stages of hardening.

Since the autumn of 1933 and up to the moment of writing we made a number of experiments to elucidate the second phase of hardening in grain. The experiments were carried out as follows. The grains were soaked after the method adopted by T. D. Lysenko in the yarovization of corn, i. e. three times up to 50 p. c. moisture in the grain. The sprouting seeds were placed in metal boxes and kept in refrigerated chambers at temperatures of +2 to +8°, 0°, and —1° for 40—80 days. The grains were then planted in furrowed soil in earth-filled boxes. The grains were not buried in the earth. The sowing took place in a cold room, at temperature of about 0 to +3°. The boxes were then removed to chambers with temperatures varying from —3 to —6° according to the experiment, and kept there from 5 to 20 days. After these two stages of hardening, the grains were subjectet to freezing, for 10 hours, at various harmful temperatures. After freezing, the boxes containing the grains were put in a cool place for slow thawing. After thawing the boxes were transferred to a warm conservatory. Upon completion of germination, a computation was made of the grains that had germinated. The experiments included some varieties well known for their resistance to frost. Beginning with the most frost resistant varieties and ending with the least frost resistant ones, the varieties mentioned herein may be classed in the following order: Eliseyevskaya rye, 0329, 0118, 0237, Ukrainka, Kooperatorka and Schroeder—winter wheats, and 0122, 0274—spring wheats. The results of some experiments are given below.

The following experiment (Table 1) shows that the resistance of sprouting grains to low temperatures is greatly increased in the second phase. In this experiment, the duration of the first phase of hardening was 50 days, that of the second, 11 days.

Table 1

Percentage of Germination of Grains after Freezing at a Temperature of —15°

Varieties of winter wheats	First phase of hardening: 50 days at temperatures of:					
	2 to 8°	0°	— 1°	2 to 8°	— 0°	— 1°
	Second phase of hardening (11 days) from —3 to —6°			5 days before freezing from 0 to +2°		
0118	66	60	56	0	0	0
0237	44	34	74	0	0	0
Ukrainka	36	24	52	0	0	0

Table 2 shows the results of freezing grains of 7 varieties of wheat, kept for 80 days at a temperature of 0 to —1° and subsequently, for 10 days, at a temperature of —3 to —6°.

Table 2

Percentage of Germination of Grains after Freezing

Varieties of wheat	Temperatures of freezing		
	— 12°	— 18°	— 20°
Winter Wheats			
0329	63	32	19
0237	64	17	8
0118	72	12	8
Ukrainka	77	5	2
Kooperatorka	71	2	0
Spring wheats			
0122	35	0	0
0274	30	0	0

In the experiment given below (Table 3), the first phase of grain hardening took place at temperature of +2° to +6° and lasted for 60 days, the second phase at temperatures of —3° to —6° and lasted for 10 days.

Table 3

Percentage of Germination of Grains after Freezing at —18°

Varieties of winter wheat	First phase of hardening at temperatures of	
	2° to 6°	0°
0329	58	—
0118	44	49
0237	44	42
Ukrainka	21	11
Kooperatorka	17	12

The above data, yielded by the investigation of the resistance to frost of sprouting grains subjected to two consecutive phases of hardening, show differences of frost resistance in a number of varieties of winter wheat. Very important is the fact that the varieties subjected to the second phase of hardening in grain, and classed according to frost resistance appear to be placed, in the majority of cases, in the same order as when their resistance to frost is tested after hardening the green plants. In addition to this, the above data show that the first stage of hardening at temperatures of about 0° (above 0°) does not extend beyond a certain limit, 50, 60 or 80 days of hardening giving at that stage exactly the same results.

A number of tentative experiments made by us in order to determine the best method of grain hardening show that the first phase follows a satisfactory course if the temperature is kept at about 0° for 20—40 days. Thus the whole process of determining the frost resistance from sprouting grains can be performed in less than two months, it being possible further to reduce this period to a considerable extent.

One of the main difficulties that are in the way of a further development of the method suggested is the moisture of the grain. It had been demonstrated by the very first experiments made in 1932 that the resistance to frost was

greatly affected by the content of moisture in the grains. Owing to differences in size, texture, snrface, etc., the swelling of the grain due to soaking is far from uniform, which greatly affects its hardening; it is therefore imperative to devise a method that would ensure a constant and definite moistening of the grains during the hardening process.

Conclusion

The selection of winter hardy forms of wheat from hybrids or population varieties takes, even now that artificial refrigeration is applied, little under a year. It is desired to develop a method that would admit of a quicker selection of frost resistant forms. The experiments made by us in 1932—35 with a view to studying the frost resistance of soaked and sprouting grain warrant the following conclusions:

1) If grains are soaked and begin to sprout at room temperature and are subsequently kept for about 40 days at temperatures of about 0° (above 0°), the plants of wheat and rye can be inured to low temperatures (down to about —12°), i. e. to the same extent as green plants that have passed through the first phase of hardening. Grains need no light while passing through the first stage of hardening. At the first stage, the hardening of grains is due to the conversion of the starch contained in the endosperm into sugar.

2) Upon completion of the first phase of hardening, the grains may pass through the second phase lasting 5—20 days at temperatures below 0° (in our experiments, —3 to —6°). In the second phase, the grain becomes hardenend to temperaturs of and below —18°.

3) After passing through the first and the second stage of hardening as soaked and sprouting grains and after having been subsequently subjected to freezing at temperatures so low as to be harmful, the different varieties of wheat remain in the same respective positions as regards resistance to frost as when their hardened green plants are tested for frost resistance.

4) When an adequate method of grain hardening at low temperatures has been finally established, it will be easy to devise a simple and convenient procedure for determining the resistance to frost of winter varieties in a laboratory and in any season of the year.

5) The problems of hardening sprouting grains to low temperatures are of signal importance in the case of late autumn (sub-hibernal) sowings of winter varieties (so late that no sprouting takes place in autumn), as well as in the case of superearly sowings of spring varieties.

In 1934—35, the winter varieties that had been sown in the fields of the All-Union Institute of Plant Breeding and Genetics and had failed to sprout in autumn, offered the following picture: the Eliseyevskaya cold resistant winter rye and winter wheat 0237 sprouted well in spring, whereas the Kooperatorka, a non-hardy variety, perished altogether. In the winter of 1934—35, the temperature of the soil in the winter wheat fields fell as low as —16 to —17° in the sowing horizon. Thus, the swollen grain, even if placed in natural euvironment in winter, may show a high resistance to low temperatures.

The persons enumerated below took part in the carrying out of the above experiments: V. Grečanovskij in 1932/33, I. Zabava in 1934, and S. Harčenko in 1935.

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PLANT PHYSIOLOGY

FROST RESISTANCE OF SPRING WHEATS

(ON THE EFFECT OF LENGTH OF THE «LIGHT» STAGE ON THE HARDINESS OF WHEATS)

By E. S. SAPRYGINA

(*Communicated by A. A. Richter, Member of the Academy. 11. VIII. 1935*)

The frost resistance of spring wheats is associated with their early maturity; the earlier a spring variety reaches maturity, the less frost resistant it is when sown in autumn. So in M. I. Saltykovskij's experiments in Saratov, when he sowed spring wheats in the autum of 1929/30 under conditions of snow retention, the following results were obtained (expressed in percentage of winter-killed plants): 0321 (West Siberian), 3 p. c.; 0274 (Odessa), 59 p. c.; 0721 (Saratov), 96 p. c.; 062 (Saratov), 97 p. c.; and Prelude (American), 100 p. c. The order of these wheat varieties if ranged according to their «earliness» will be the same as that given for their winter-hardiness. The latest in ripening under conditions prevailing at Saratov is the 0321 variety, 0274 is earlier, still more so are 0721 and 062, and the earliest of all is the Prelude.

In the autum of 1932 the spring wheats 0274 and 062 were sown in the open in Odessa. Of those sown very late a certain percentage survived the winter. But all the plants of the early and medium sowing perished. It was possible to presume on the basis of these data that the main cause of the different frost resistance of spring wheats is the length of the autumn day acting on the plants. The first stage in spring wheats, namely the stage of yarovization, is of very short duration.

This set us the question of elucidating the effect of the length of the «light» stage on the frost resistance of spring wheats. For this purpose, in 1933 and 1934 we analysed the autumn conditions affecting the frost resistance of spring wheats.

In 1933 these experiments were commenced under laboratory conditions in March and terminated in summer. Unjarovized seeds were used; they were cultivated under a short 9 hour day, normal (13—14 hour) day, continuous day, and changing day. The spring wheat was hardened in an artificially cooled chamber at a temperature of from +4 to 0° C.

In order to obtain for our experiments of 1933/34 plants at different stages of development, we sowed both jarovized and unjarovized seeds, cultivated the plants under different light régimes, and sowed at two different dates (September 3 and October 3) in vegetative pots. The sowings of yarovized and unyarovized wheats gave similar results in our experiments, and therefore we shall in future speak of unyarovized sowings only. Both in the experiments of 1933/34 and in those of 1932/33, the 0274 spring wheat was the material investigated. The plants of the first sowing date were

divided into 2 groups. The first group was grown from the moment of emergence under 8 hours, 10 hours and normal day-length (13, 12 hours). The second group was grown under an 8 hours day, normal day and continuous 24 hour illumination. A shortening of the day-length was effected both in 1933/34 and in 1933 by covering the plants with plywood boxes. Continuous illumination was provided by electric light of about 500 lux during night hours. The temperature régime was the same for all the plants, as they were all grown in the open. Plants of the second sowing were grown under 8 hour, 10 hour and normal day-length. Such a régime was continued for 30 days. The plants cultivated under different light régimes differed from each other in their appearance. Plants of 8 hour day-length had a greater number of stems, smaller stature and deeper colour of the leaves, as compared with plants of normal day-length and especially those of continuous 24 hour day-length. The 10 hour day plants occupied an intermediate position between these groups.

In Table 1 we give the data on the number of stems and the stature of the plants, expressed as the mean for 110 plants of each group.

Table 1.

1st group of plants Day-length in hours	Number of stems	Stature in cm	2nd group of plants Day-length in hours	Number of stems	Stature in cm
8 hours	33	31	8 hours	25	26
10 »	27	33	Normal day (13—12 hours)	20	31
Normal day (13—12 hours)	20	38	24 hours	14	48

A month after emergence, half the plants in both groups were transferred to an artificially cooled light chamber for hardening. The other half was left in the open for natural hardening. Artificial hardening was accomplished in 2 phases (after I. I. Tumanov). The first phase continued for 10 days at from +4 to 0° C. The second phase was also continued for 10 days at from —2 to —3.5° C.

After hardening a series of freezings was effected in refrigerating chambers at —4, —7, —9, and —10° C, and in the open at —9.5 and —11° C. The freezing was in all the cases repeated three times. When the plants had ceased to die (on the 15th—20th day after freezing), the number of plants killed was recorded. Tables 2 and 3 show the results of these records expressed as the mean for 30 plants.

Table 2

Percentage of Frost-Killed Plants of the 0274 Spring Wheat
(Experiment of 1933)

Day-length	Temperature			
	—7°	—8°	—9°	—10°
9 hours	22	15	13	89
Normal (13—14 hours)	26	62	61	96
24 hours	69	94	89	100

Table 3

Percentage of Frost-Killed Plants of the 0274 Spring Wheat
(1st date of sowing, experiment of 1933/34)

	Temperature of freezing	1st group			2nd group		
		Day length					
		8 hours	10 hours	Normal (13—12 hours)	8 hours	Normal (13—12 hours	24 hours
Freezing in refrigerating chambers	— 4	27	48	62	20	47	87
	— 7	40	94	97	53	80	100
	— 9	84	90	100	93	100	100
	—10	100	100	100	100	100	100
Freezing by natural frost	— 9.5	86	90	100	70	87	100
	—11	92	100	100	90	100	100

The above data show that the injury sustained by plants cultivated under a short day is 2, 3, 4 and even 6 times less than that sustained by plants cultivated under a 24 hours day.

Besides, in the experiments of 1933/34, as well as in those of 1932/33, the spring wheat of later sowings was found to be much more resistant than that of earlier sowings, as will be seen from Table 4.

Table 4

Percentage of Frost-Killed Plants (experiments of 1933/1934, 0274 spring wheat, temperature—11° C)

Sowing date	Day-length		
	8 hours	10 hours	Normal (13—12 hours)
Early sowing (3. IX)	92	100	100
Late sowing (3. X)	21	73	100

The same was confirmed by experiments of 1934/35 with spring wheats 0274, 0321 and a finnish variety from the extensive collections of the All-Union Institute of Plant Industry (No 3439, T. D. Lysenko's station, 1934). The early sowing was on September 9, the late sowing on October 21. Determinations of frost resistance made in February showed the following results.

Table 5

Percentage of Frost-Killed Plants (experiments of 1934/35)

Varieties	— 8° C		— 12° C	
	Sowing date			
	9.IX	21.X	9.IX	21.X
Spring wheat 0321	80	0	100	67
» » 3439	90	64	100	100
» » 0274	100	100	100	100

The explanation of all the above-described phenomena became obvious after T. D. Lysenko had evolved his theory of the growth of plants. In the 0274 spring wheats the first stage is of brief duration. It is passed by plants in autumn, while the weather is still warm enough (10, 12° C.). By shortening the day-length, we retard the development of the plant during its first stage. Continuous «tillering» under a short day produces side stems which stay at the first stages of development. Under normal day-length this wheat can enter the «light» stage and pass, if not the whole of it, at least sertain of its substages. Additional illumination accelerates the passage of the plant through the «light» stage. It retards or prevents tillering, and all the stems of these plants go very far in their development. When plants at so different stages of development were subjected to hardening at low temperatures, as described above, it was found that plants cultivated under an 8 hour day were still in the first stage of development, and hardened well; plants cultivated under normal day-length had already entered the «light» stage and did not harden so well; while plants which had been cultivated under continuous illumination and had passed through the second stage, had lost almost all powers of hardening. Thus, at a temperature of —4 C. only 20 p. c. of plants of an 8 hour day-length and 87 p.c. of those of a 24 hour day-length perished.

We explain the better frost resistance of spring wheats of late sowing as follows: as a result of late sowing, plants of a younger stage of development are obtained, since a shorter day and a lower temperature towards the end of autumn retard the development of the second stage; if the day be artificially shortened still more, the second stage will be quite excluded, which enables the plant to harden better and makes it more frost resistant.

Cur conclusions are confirmed by agricultural practice. In southern latitudes, as in North Caucasus, Trans-Caucasia, etc., spring wheats are cultivated as winter ones not only because of the winter being warmer but mainly because, owing to the late autumn and winter sowings practised there, the plants find themselves under short-day conditions. The short-day retards or even prevents the development of the second stage. This retardation makes for a better hardening of the spring wheats, as compared with those that have attained further development, and thus enables them to endure low winter temperatures, which sometimes fall here to —10, —12°C and lower. The longer the second stage in spring wheats with a very short first stage, the greater their frost resistance, and therefore spring wheats of a long «light» stage can have economic importance in a number of southern regions for winter sowing. Thus frost resistance of wheats depends, not only on the length of the first stage, i. e. yarovization, but also on that of the second stage.

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ZOOLOGIE

FAUNISTISCHE FORSCHUNGEN IM WOLGA-URAL-SANDGELÄNDE

(MAMMALIA)

Von J. M. RALL

(Vorgelegt von S. A. Zernov, Mitglied der Akademie, d. 14. IV. 1935)

Die Durchsicht der einschlägigen Literatur, sowie der Sammlungen des Zoologischen Museums der Akademie der Wissenschaften der UdSSR und des Moskauer Zentralen Zoologischen Museums zeigte die Unvollständigkeit und zum Teil sogar Irrtümlichkeit unserer Vorstellungen über die Fauna des Wolga-Ural-Sandgeländes. Vorliegende Mitteilung verfolgt den Zweck, Klarheit in dieser Beziehung zu schaffen und die Ursachen der erwähnten Fehler anzugehen.

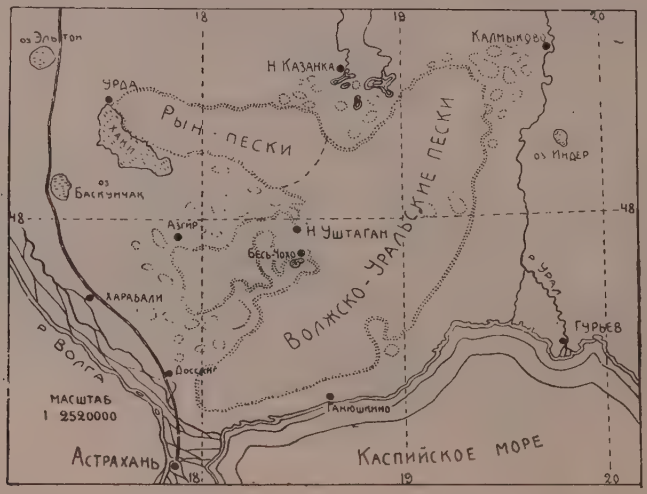
Das zwischen dem Unterlauf der Flüsse Wolga und Ural südlich des 49° n. Br. gelegene Sandgelände figuriert in der Literatur unter den Bezeichnungen: «Kirghisensteppe», «Transwolga-Sandgelände», «Astrachanisches Sandgelände», «Wolga-Ural-Steppen», «Westkazakstanisches Sandgelände» u. a., wobei bald das eine, bald das andere Territorium gemeint wird, am öftesten jedoch die ganze Steppen- und Sandfläche zwischen dem Unterlauf der angegebenen Flüsse. Eine unbestimmte Terminologie finden wir auch in den neusten Arbeiten. S. Obolenskij schreibt 1927 über die «Bukeevskaja-Steppe (1), während W. Heptner in seiner Notiz über *Gerbillinae* (2), nachdem er direkt angegeben: «das zwischen Wolga und Ural gelegene Land (Ryn-Peski)», fortfährt diesen Termin auch weiter anzuwenden. Eine gewisse geographische Unklarheit ist hier schon von P. Pallas verschuldet worden, der ausgedehnten Gebrauch vom Ausdruck «Ryn-Peski» machte und damit die «terra typica» vieler von ihm diagnostizierten Arten bezeichnete.

In Wirklichkeit sind die «Ryn-Peski» nur ein unbedeutender Teil im Nordwesten des Sandmassivs und nehmen nur $^1/_{10}$ der Gesamtfläche des Wolga-Ural-Sandgeländes ein. Indem ich letzteren Termin zur Bezeichnung unseres Gebietes wähle (3), werde ich mich im Nachfolgenden an ihn halten.

Unter dem Wolga-Ural-Sandgelände ist nicht das ganze Gebiet zwischen diesen Flüssen, welches im Süden vom Kaspischen Meer und im Norden von der 49-ten Parallele begrenzt ist, zu verstehen. Innerhalb dieser Fläche nimmt das mosaikartig verteilte Sandsteppengebiet ein bestimmtes Territorium von ungefähr 4.500 000 ha Ausdehnung ein, wie aus unserer Kartenskizze ersichtlich ist.

Ausserhalb der natürlichen Grenzen des Sandgeländes erstrecken sich die Salzbodensteppen des Transwolga- und Uralgebietes, die Uferzone am Meer und das Wolgadelta. Von diesen Nachbargebieten hat jedes seine ihm eigen-

tümlichen Existenzbedingungen und charakteristischen Biozönosen. Die Biozönosen der Steppe, des Sandgeländes und der Uferzone tauschen an ihren Grenzen manche ihrer Glieder gesetzmässig durch säkulare Succession miteinander aus, während andere ihrer Glieder sich nur innerhalb eines schmalen Streifens des ihnen gemeinsamen Areals finden, und noch andere periodisch je nach der Saison aus einem Wohngebiet in das andere wandern (insbesondere gefiederte und vierfüssige Räuber). Die wellenartige «Uferlinie» des Sandgeländes mit unzähligen «Buchten» der Steppe und mannigfaltigen Stationen erleichtert diese Wanderungen. Die Randstreifen des Sandgeländes können also keinen richtigen Begriff von der Fauna der inneren Teile geben.



Überdies unterscheiden sich die «Ryn-Peski» scharf von anderen sandigen Gebieten durch höhere Feuchtigkeit, Baum- und Strauchwuchs sowie verschiedenartige Grasvegetation, wodurch manche Arten, die dem ganzen Sandmassiv nicht eigentümlich sind, die Möglichkeit erhielten, sich in den Ryn-Peski auszubreiten. Gerade dieser Winkel ist auch am besten erforscht. Vor 1928 sind Zoologen nicht ins Innere des Sandgeländes eingedrungen, sondern haben nur Exkursionen in der Umgegend von Chanskaja Stavka (jetzt Urdà), Tschaptschatschej (Azgir), Choscheutov, Dossang, Besj-Tschocho, Kalmykov, Stavka Beka-Muchamedova, Dzhangala, (Novaja Kazanka) und einiger Stationen der Uralischen Poststrasse am Rande des Sandgeländes unternommen. Ich konnte das mit voller Gewissheit feststellen, indem ich die Reiserouten von Pallas (und seinem Gehilfen Sokolov), Gmelin, Eversmann, Satunin und anderen Reisenden wiederherstellte. Bemerkenswert ist, dass in dem ausführlichen Literaturverzeichnis über das Astrachansche Gebiet (4) von 5848 russischen und fremdsprachlichen Arbeiten nur 9 dem Sandgelände gewidmet sind, und die meisten von diesen—den Ryn-Peski. Diese Tatsachen sprechen für sich selbst. Die meisten Forscher schrieben also die am Rande des Sandgeländes gemachten Beobachtungen dem gesamten Sandmassiv zu, ohne die faunistischen Besonderheiten der Randstrecken zu berücksichtigen; in gegenwärtiger Zeit dauert die kritiklose Anführung dieser Angaben fort.

So werden von Nagern *Sciertopoda tellum* Licht., *Rhombomys opimus* Licht., *Lagerus ruteus* Ev., *Micromys minutus* Pall., *Cricetus cricetus* L., *Apodemus agrarius* Pall., *Sicista nordmanni* Keys. et Blas., *Gerbillus eversmanni* Bogd., *Microtus socialis* Pall., *Spalax* giganteus Nehr., und sogar *Lepus tolai* Pall.Ohne jede Einschränkung für das Wolga-Ural-Sandgelände nicht nur in den zur Genüge bekannten Arbeiten von Pallas, Eversmann, Karelin und Satunin angeführt, sondern auch in neuerer Zeit von Vinogradov (5), Ognev (6) und Beljaev (7). Von Säugetieren anderer Gruppen werden mehrfach angeführt: *Vulpes corsac* L.*, *Mustela sarmatica* L., *Erinaceus roumanicus* Bar.-Ham., *Sorex*-Arten und sogar der Manul (*Otocolobus manul* Pall.).

Andererseits werden manche Arten des Wolga-Ural-Sandgeländes in der Literatur nicht erwähnt. So sind Satunin nicht weniger als 6 im Sandgelände vorkommende Arten entgangen, darunter eine so charakteristische wie *Meriones tamaricinus* Pall.(8). In der auf Angaben Jakovlev's beruhenden Mitteilung Kesslers (9) wird über *Citellus pygmaeus* Pall. (=*Spermophilus mogozaricus* Licht.) auf dem linken Wolgaufer besonders bemerkt, dass dieses Ziesel nicht im Sandgelände vorkomme, wo sich ausschliesslich *Spermophilus fulvus* Licht. (=*Citellus fulvus* Licht.) aufhalte. Gegenwärtig ist das Vorkommen des kleinen Ziesels im Wolga-Ural-Sandgelände gut bekannt [Vgl. beispielsweise Rall und Chudjakov (10)]. In der unlängst veröffentlichten (1934) Liste der Nagetiere Kazakstans von Beljaev (7) figurieren die Termine «Süden der Wolgasteppe», «Süden des Westgebiets», «Untrerlauf des Ural», «Kaspische Küste» nebeneinander. In der Arbeit werden Arten angeführt, deren Vorkommen hier entschieden in Abrede gestellt werden muss, während die Verbreitung der Springmäuse und Gerbillinen mit einer Annäherung bis auf 500 km angezeigt ist.

Während der sechs Jahre unserer kollektiven Forschungen** im Wolga-Ural-Sandgelände, die vom Saratovschen Institut für Mikrobiologie und Epidemiologie des Südostens der RSFSR (Direktor V. A. Byčkov) durchgeführt wurden, sahen wir dort keine Spur mancher von den erwähnten Tieren, obgleich unsere Resultate auf ununterbrochenen Beobachtungen (das ganze Jahr hindurch) und einem Material von mehr als 10 000 Kleinsäugetieren und mehr als 10 000 analysierten Gewöllen gefiederter Räuber beruhen***. Dieser Widerspruch ist leicht verständlich, wenn man die wahrhaft unklaren Vorstellungen der Zoologen über die Geographie des Wolga-Ural-Sandgeländes und die Kürze ihrer faunistischen Untersuchungen berücksichtigt.

Der Artbestand der wildlebenden Säugetiere, die von uns mit Sicherheit an verschiedenen Orten in dem eigentlichen Wolga-Ural-Sandgelände (ohne Ryn-Peski) nachgewiesen sind, ist folgender: Insectivora: 1) *Hemiechinus auritus* Gmel., 2) *Crocidura suaveolens suaveolens* Pall., 3) *Diplomesodon pulchellum* Licht.; Chiroptera: 4) *Vespertilio murinus murinus* L. (während der 4 Jahre unserer Arbeit nur ein Exemplar bemerkt und erbeutet); Glires****:

* In meiner Notiz über das Sandgelände (3) habe ich leider den Fehler Satunins wiederholt und *Lepus talai* sowie *Vulpes corsac* aus unserem Gebiet erwähnt.

** An diesen Forschungen beteiligten sich die Zoologen: A. A. Flegontova, M. V. Šejkina und der Autor, unter der Leitung des Doz. B. K. Fenjuk.

*** In der Sammlung des genannten Instituts befinden sich 600 Säugetierexemplare; ein Teil wurde den zentralen Museen in Moskau und Leningrad übergeben.

**** Diese Gruppe wurde von mir im zoologischen Museum der Akademie der Wissenschaften der UdSSR und im Moskauer zentralen Museum unter Konsultation von Prof. B. Vinogradov, S. Ognev und W. Heptner bearbeitet, denen ich hier meinen tiefen Dank ausspreche.

5) *Citellus pygmaeus pygmaeus* Pall., 5a) *Cit. pygm. pallidus* n. *arenicola* Rall.*, 6) *Cit. fulvus* Licht., 7) *Alactaga elater elater* Licht., 8) *Alactaga jaculus (decumanus?)*, 9) *Alactagulus acontion acontion* Pall., 10) *Dipus sagitta innae* Ogn., 11) *Mus musculus wagneri* Eversm., 12) *Microtus arvalis rossiae-meridionalis* Ogn., 13) *Lagurus lagurus lagurus* Pall., 14) *Ellobius talpinus (talpinus?)*. 15) *Cricetulus migratorius migratorius* Pall., 16) *Allocricetulus eversmanni belaievi* Argo., 17) *Miriones tamaricinus tamaricinus* Pall., 18) *Pallasiomys meridianus meridianus* Pall., 19) *Lepus europaeus caspius* Erxl; Carnivora: 20) *Canis lupus* L., 21) *Vulpes vulpes (karagan?)*, 22) *Putorius eversmanni* Less., 23) *Mustela erminea* L., 24) *Mustela nivalis* L., 25) *Meles leptorhinchus arenarius* Satun; Ungulata: 26) *Saiga tatarica* Pall.

Ausserdem sind in der Umgebung von Urdà (Ryn-Peski) mit seinen Pappelhainen nach unseren Untersuchungen und Literaturangaben festgestellt: Insectivora: 1) *Erinaceus rumanicus* Bar.-Ham., Chiroptera: 2) *Myotis daumentonii volgensis* Ev., 3) *Nyctalus noctula princeps* Ogn., 4) *Pipistrellus nathusii* Keys. et Blas., 5) *Nyctalus leisleri* Kuhl., 6) *Eptesicus serotinus turcomanus* Ev. (letztere Art ist nicht mit Gewissheit festgestellt); im übrigen Teil des Sandgeländes fehlen Chiropteren fast; Glires: 7) *Cricetus cricetus* L., 8) *Apodemus sylvaticus mosquensis* Ogn., 9) *Sicista (Nordmanni* Keys. et Blas., 10) *Rattus norvegicus* Erxl. (in Gebäuden der Stadt Urdà). Auch ist die Möglichkeit des Vorkommens von *Pygerethmus platyurus* Licht., *Scirtopoda tellum* Licht., *Apodemus agrarius* Pall. und Vertretern der *Muscardinidae* in den Ryn-Peski nicht ausgeschlossen.

Die faunistische Charakteristik des Gebietes bei Novaja Kazanka und anderer analoger Punkte mit Süsswasserseen lasse ich fort, da sie sehr eigenartig sind und geographisch nur an das Sandgelände grenzen.

Das sind unsere Vorstellungen vom Artbestand der rezenten Säugetierauna des Wolga-Ural-Sandgeländes.

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d. 14. III. 1935.

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* Die Diagnose dieser natio ist in meiner Arbeit ([11]) gegeben.

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PALEOZOOLOGY

A FIND OF *THYSANOPTERA* IN THE PERMIAN DEPOSITS

By A. V. MARTYNOV

(Communicated by A. A. Borissjak, Member of the Academy, 8. V. 1935)

Till now *Thysanoptera* have been known but from the Tertiary deposits, and only one form has been described (1927) from the Jurassic of North Turkestan. The relationship and the phylogeny of this order remain very obscure. According to Handlirsch, *Thysanoptera* are somewhat related to *Orthoptera*, Karny and Priesner believe they are more allied to *Zoraptera*, while Imms considers them as standing nearer to *Homoptera*. In any case, the order *Thysanoptera* is very distinct and much differing from other orders, and therefore its stem must be very old. At present I have gained an opportunity of substantiating such a presumption by the find of several remains which belong to this order in the Permian deposits. I discovered these interesting remains in 1931 in the village Sedy, Kungur district (Permregion). Here, in the vicinity of the village, there is a locality of sandy shales with scarce remains of plants, and on some of the plate-like pieces were revealed several remains of small insects reminding one of *Thysanoptera*. Unfortunataly the preservation of these remains proved to be poor. In most specimens only dark pieces of the segments of abdomen and thorax are preserved; wings are without venation; as regards legs, only femora and parts of tibiae are preserved; tarsi are not preserved. I made (with the aid of Abbes apparatus) several drawings of what I had found, but they cannot be considered very accurate. I am very much obliged to O. Skalon for her assistance in making a comparison with recent forms

Permothripidae n. fam

Head somewhat extended, as in many recent *Phloeothripidae*. Pronotum transverse, narrowed anteriorly, as in *Phloeothripidae*. Mesothorax and metathorax already united into the pterothorax similar to that in recent forms;

one may usually discern, above, a pale tranverse band separating the large anterior from the smaller posterior portion. Legs short, the tibiae being more slender than the femora. Wings long, somewhat extending behind the end of abdomen, elongately elliptic. Abdomen narrowed in its end portion, as in recent *Thripidae*; ovipositor, apparently, present.

Permothrips longipennis, n. gen. n. sp.

No 2506 (4, 10, 12a, 15, 16). Village Sedy, Kungur district, Permregion, 1931, A. M. (Probably Lower Kazanian). About thirty specimens. The biggest of them is represented by abdomen and thorax with wings, but

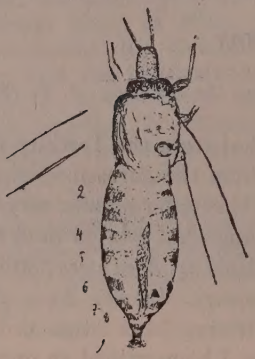

Fig. 1.

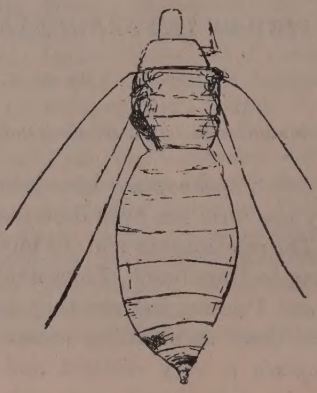

Fig. 2.

in small specimens head, basal parts of legs and of antennae are also preserved; venation of wings indiscernible, preservation of thorax is also rather poor.

Head small, elongately subquadrangular (Fig. 1, 2), as in many recent *Phloeothripidae*; antennae, apparently, short and thick (indistinct). Pronotum transverse, narrowed anteriorly, in its shape similar to that in recent forms.

Pterothorax resembling that in recent forms, the boundary between its anterior and posterior portions distinct. Wings long, elongately elliptic (venation not preserved). Legs short, femora short and moderately thick, tibiae slenderer. Abdomen narrowed in its end portion (segments 7—10), as in the fam. *Thrypidae*; its segments are well seen in some specimens. In the middle of three distal segments (7—9), one may discern in some specimens a slender brown median rod-like structure representing probably the ovipositor. In some specimens in front of it are situated two divergent brown bands, the morphology of which remains obscure to me. Length of podies in adult specimens about 3 mm.

The just described genus and species is poorly preserved, and its wing-venation, as well as the structure of tarsi, remain unknown. Nevertheless, to

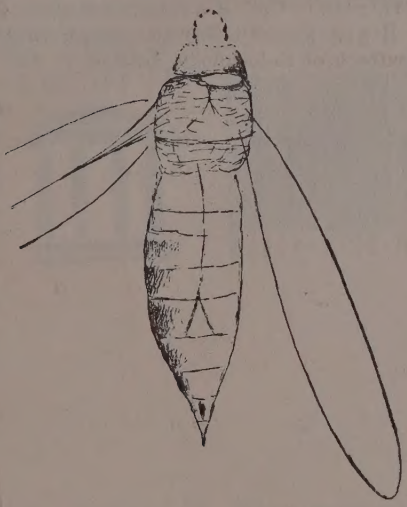

Fig. 3.

Fig. 4.

judge from the shape of the abdomen, thorax, and head, one may conclude that it belongs to the order *Thysanoptera*.

In the structure of body and head it unites some features of both known recent suborders of the order: in the form of the head and the pronotum it resembles *Tubulifera*, in the form of the abdomen, *Terebrantia*. Pterothorax in *Permothrips*, gen. n. is already formed and resembles that in recent forms, while the pale transverse band on it corresponds probably to the same band in the pterothorax of recent forms and probably separates the mesothorax+the anterior portion of the metanotum from the metathorax (without the anterior scutum*).

On the basis of the features mentioned above, I consider the genus *Permothrips* n. gen. as representing a distinct family and, perhaps, even a new suborder.

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* The morphology of the posterior scutum of the metathorax in Thysanoptera is not quite clear. If the anterior scutum is a true metanotum, the posterior appears to me to represent rather the metapseudonotum.

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